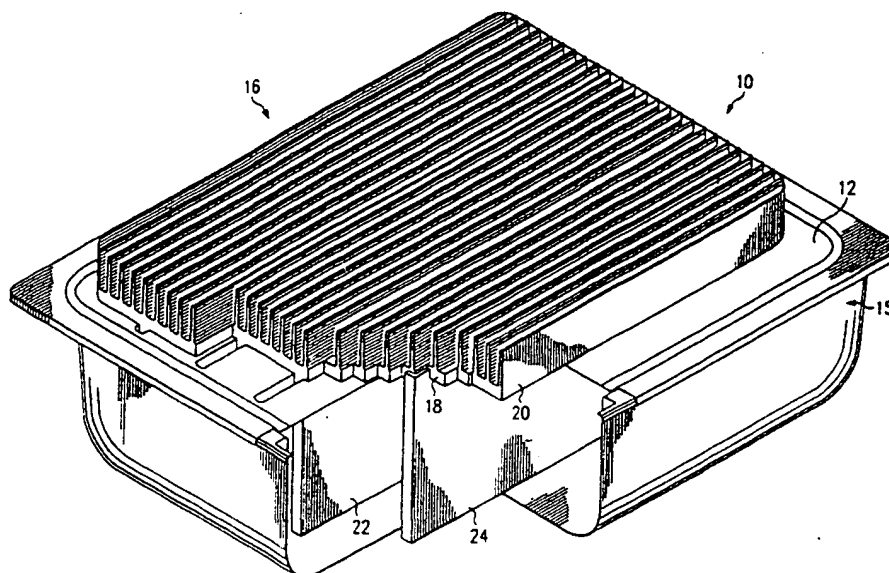




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/US98/17433 (22) International Filing Date: 25 August 1998 (25.08.98) (30) Priority Data: 08/919,526                      28 August 1997 (28.08.97)                      US (71)(72) Applicant and Inventor: GIACOMEL, Jeffrey, A. [US/US]; P.O. Box 201444, Arlington, TX 76006-1444 (US). (74) Agents: GUSTAVSON, William, R. et al.; Sidley & Austin, Suite 3400, 717 North Harwood, Dallas, TX 75201 (US).	(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  Published With international search report.	

(54) Title: FOOD PREPARATION AND STORAGE DEVICE



## (57) Abstract

A food storage and preparation device (10, 50, 100) is provided for more rapidly cooling or heating a mass of food or other product contained within a storage pan. The device includes a plurality of air contact fins (20) which rapidly convey heat to and from the ambient surrounding air and a plurality of food contact fins (22, 56, 106) which are inserted within the mass of food to increase the surface area of the food exposed to a heat transfer surface to more rapidly transfer heat to or from the mass of food.

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## **FOOD PREPARATION AND STORAGE DEVICE**

### **TECHNICAL FIELD OF THE INVENTION**

This invention relates to the preparation and storage of food and other materials of a commercial and industrial nature such as cosmetics, pharmaceuticals and other organic and inorganic materials, and in particular to a device for rapidly cooling and  
5 heating food.

## BACKGROUND OF THE INVENTION

In the food preparation industry, the rapid cooling or heating of food is very critical. For example, when a large batch of food is prepared, for example, a stew, beans or the like, health food regulations, and safety requires the food to be cooled  
5 within a certain time period from the cooking temperature, (perhaps 140-165°F) to the storage temperature of 40°F. The longer the food takes to cool, the longer the food will be at a temperature range conducive to the growth of harmful bacteria and the like which can spoil the food and cause illness.

The commercial food industry, for example, will often use manual labor to take  
10 large volumes of hot food and place them in plastic bags for protection and submerge the bags and food in ice baths to cool the food from the cooking temperature to the storage temperature. This is a very costly procedure given the energy and labor input that is required each time the procedure is undertaken. In addition, the bags are used to subsequently reheat the food. This process of using bags involves physically handling  
15 the food at each bag iteration. It often takes more than a four hour period to cool the food from the cooking temperature to the storage temperature. In addition to the bags and the ice baths, quite often the food is broken down into smaller pans to facilitate cooling. Again, this results in a waste of labor, energy and food and results in an increased possibility of cross-contamination. Many jurisdictions have regulations that  
20 limit the time for this cooling procedure and this must be monitored continuously.

In heating the food just before serving, time is also critical. It is desirable to keep this time as short as possible to give the preparer greater flexibility in the timing of the final meal service. Further, the shorter the interval of time to heat the food, the less time the food will be exposed to a temperature range conducive to the growth of  
25 bacteria. Also, less energy is required to heat the product to temperature and less product is lost to burning or dehydration at the edges nearest the heat source due to non-uniform heating of the product.

A need exists for a process to more rapidly heat and cool food to provide the advantages of a safer food service and to satisfy the applicable regulations, reduce energy, labor and product loss due to inefficient thermal effects.

## SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention, an apparatus is provided for rapidly changing the temperature of a mass of product. The apparatus includes at least one input heat transfer element extending into the mass of product and at least one  
5 output heat transfer element exposed to an ambient temperature environment to transfer thermal energy between the input heat transfer element and the output heat transfer element.

In accordance with another aspect of the present invention, the apparatus is employed with a pan containing the mass of product. A lid is provided for the pan  
10 which has a plurality of slots therein. The apparatus includes a plurality of input heat transfer elements formed as fins, the fins extending through the slots in the lid and into the mass of product therein. The output heat transfer element is positioned exterior the lid. In accordance with another aspect of the present invention, the fins can be removable. The fins also can touch the bottom of the pan to enhance heat transfer.

15 The input heat transfer elements can extend from the top of the pan down, from the bottom of the pan upward, or horizontally from the sides.

The apparatus may be integral with the top closure of the pan or may be used with an expandable handle to facilitate removal of the apparatus from the pan.

20 Heat transfer can occur by conduction, convection and radiation.

A working heat transfer medium, either a solid, liquid or gas, can be utilized to improve the heat transfer.

## BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention and its advantages will be apparent from the following detailed description, when taken in conjunction with the accompanying drawings, in which:

5       FIGURE 1A is a perspective view of a food preparation and storage device forming a first embodiment of the present invention;

FIGURE 1B is an exploded perspective view of the food preparation and storage device;

FIGURE 2 is a plan view of the device of FIGURE 1;

10       FIGURE 3 is an end view of the upper portion of the device of FIGURE 1;

FIGURE 4 is a detail view of the exposed heat transfer fins of the device;

FIGURE 5 is a side view of one of the fins used in the lower end of the device;

FIGURE 6 is a side view of a modified fin used in the device;

15       FIGURE 7 is an end view of a device forming a first modification of the device shown in FIGURE 1;

FIGURE 8 is a detail view of the device of FIGURE 7;

FIGURE 9 is a detail view of a fin used in the device of FIGURE 7;

FIGURE 10 is a detail view of a cooling fin used in the device of FIGURE 7;

20       FIGURE 11 is an end view of a second modification of the device of FIGURE 1;

FIGURE 12 is a cross-sectional view of FIGURE 11 taken along line 12-12 in FIGURE 11;

FIGURES 13A, B, C are fins used in the device of FIGURE 11 of different lengths;

25       FIGURE 14 is a cross-sectional view of the fin of FIGURE 13C taken along line 14-14 in FIGURE 13C;

FIGURE 15 is a detail view of the fins of the device of FIGURE 11;

FIGURE 16 is an end view of a device cast, extruded, molded or machined as a unitary body;

FIGURE 17 is a detailed view of a device having a hollow body and fins containing a thermal transfer medium with thermal characteristics offering a high thermal capacitance and heat transfer rate;

5      FIGURE 18 is an end view of a device having hollow fins and body and inlet and outlet ports for passage of a coolant;

FIGURE 19 is a detailed view of the device of FIGURE 18;

FIGURE 20 is an end view of a device having a hollow body and fins with an inlet and outlet port for passage of coolant which does not use air cooled fins;

FIGURE 21 is an end view of a device incorporating a temperature monitor;

10      FIGURE 22 is a cross-sectional view of the temperature monitor;

FIGURE 23 is an end view of a removable handle used to grasp the device;

FIGURE 24 is a graph of a freezer test with 17.5 pounds of refried beans in a 20°F residential freezer unit;

15      FIGURE 25 is a graph of a freezer test for 17.5 pounds of refried beans in a 20°F industrial freezer unit;

FIGURE 26 is a reheat test of 17.5 pounds of refried beans in a 450°F industrial unit utilizing the device of FIGURE 1A;

FIGURE 27 is a graph of a cooling test for 17.5 pounds of refried beans in a pan using the device of FIGURE 1A in a walk-in industrial refrigeration unit at 40°F;

20      FIGURE 28 is a graph of a cooling test for 17.5 pounds of refried beans in a pan using the device of FIGURE 1A cooled in a walk-in industrial refrigerator unit at 40°F;

FIGURE 29 is a graph of a cooling test for 19.2 pounds of spaghetti sauce in a pan utilizing the device of FIGURE 1A in a walk-in industrial refrigerator at 40°F;

25      FIGURE 30 is a cooling test of 17.5 pounds of refried beans in a pan utilizing the device of FIGURE 1A in an industrial freezer at 20°F;

FIGURE 31 is a graph of a cooling test for 17.5 pounds of refried beans in a pan utilizing the device of FIGURE 1A in an industrial freezer unit at 20°F; and



FIGURE 32 is a graph of test results of a cooling test for 19.2 pounds of spaghetti sauce in a pan utilizing the device of FIGURE 1A in an industrial freezer unit at 0°F-20°F.

## DETAILED DESCRIPTION OF THE INVENTION

With reference now to the figures, and in particular to FIGURES 1A-6, there is shown a food storage and preparation device 10 forming a first embodiment of the present invention. The device 10 is intended to be used with a food preparation and storage pan 15 as is commonly used in the food service industry. For example, typical pans of this type might have horizontal dimensions of nine inches by twelve inches and a depth of about six inches. As will be described hereinafter, device 10 not only can provide a lid for the container, but also provides for rapid cooling and heating of the food within the pan.

The device 10 can include a lid 12 which has a series of linear slots therethrough. The lid 12 is designed to fit commonly used pan designs found in the food industry today. In addition, the device 10 includes a heat transfer assembly 16 which includes a body 18 forming a plurality of air contact fins 20 and a plurality of food contact fins 22. The food contact fins 22 are positioned on the body 18 to fit through slots 14 in the lid 12 and enter the mass of food or other product within the pan 15 on which the lid is positioned. If desired, the bottom edges 24 of the food contact fins 22 can contact the bottom of the pan.

The heat transfer assembly 16 is preferably formed of a material having a high coefficient of thermal conductivity. For example, the assembly 16 and lid 12 can be made of aluminum, stainless steel, cast iron, copper, high thermally conductive plastics, polymers, polyimides, organic or inorganic structures, or other suitable material. The material can be sandwiched or coated or a combination thereof provided that the heat transfer capability is satisfactory utilizing the preferred heat transfer characteristics of solid, liquid or gas.

As can be appreciated, the assembly 16 provides for more rapid heat transfer between the mass of food within the pan and the surrounding ambient air. When the mass of food is being cooled from the cooking temperature to the storage temperature, typically 40°F, the intimate contact between the mass of food and the plurality of food contact fins 22 provides for enhanced heat transfer from the food mass into the

assembly 16. The heat transfer is rapid from the food contact fins 22 into the body 18 and air contact fins 20, where the heat is rapidly dissipated by heat transfer to the ambient air. Similarly, when the food is to be heated, such as by positioning the pan and assembly 16 in an oven, the ambient air temperature and incident radiation will rapidly heat the air contact fins 20, conveying heat to the body 18 and food contact fins 22. Because of the intimate contact between the mass of food and the food contact fins 22, the heat is more rapidly transferred into the mass of food than is possible without the use of the assembly 16.

Among its many advantages, the device 10 will allow the cooling and heating rates of prepared foods to be shortened significantly. This will also extend food shelf life and increase storage. The device will improve performance within the health code guidelines and open the storage performance envelope in terms of storage and preparation time. Health and handling hazards are reduced and the handling appropriation costs of the food are reduced. Because the food industry has for years been in the process of standardization of pans, cooking apparatus and refrigeration for food storage, the present device, which is readily adaptable to present designs, reduces additional costs to a minimum. Other industrial and commercial applications of device 10 in such areas as cosmetics or pharmaceuticals would only require the scaling up or down in size of the device along the design parameters of the invention. The device 10 is also passive in the performance of its function, requiring a minimum of human interaction and thereby limiting the cross-contamination of the product. As seen in FIGURES 5 and 6, shorter food contact fins 22a can be used for shallower pans while deeper food contact fins 22b can be used for deeper pans. The fins 22 fit within slots 26 (FIGURE 3) formed in the bottom surface 28 of the body 18 which allow different size fins to be mounted on a single design of body 18. The fins 22 can be welded, brazed, bonded, soldered, pinned, or otherwise attached to the body 18. The attachment can be permanent or removable. The air contact fins 20 are preferably formed integral with body 18 and also preferably are formed of a corrugated shape (FIGURE 4) having

a number of curved indentations 30 to increase the amount of surface area to enhance the heat transfer capability of the fins 20 to the ambient air.

Clearly, other configurations of device 10 can be utilized. The heat transfer assembly 16 can be used without lid 12, if desired. Further, the configuration, size and number of fins 20 and 22 can be varied as desired. Fundamentally, it is desired to have as much surface area contact between food contact fins 22 and the mass of food as is necessary to perform the desired heating or cooling function and to have sufficient surface area of air contact fins 20 to provide the desired rate of heat transfer between the ambient air and the fins 20. This device allows for variation in the size, quantity, geometry and orientation of the heat transfer members to maximize performance along the principles enumerated herein. The modular concept allows for the switching out of either the top finned segment or the entire device for a pre-frozen replacement to further facilitate the cooling of the product. The device 10 can be integral with the lid 12, or integral with the pan 15. For example, fins 22 can extend upward from the bottom of pan 15, or horizontally from the sides of pan 15.

A number of approaches to the device 10 can be taken. The device 10 can be multi-sectional, involving separable modular components which allows the addition or removal of heat transfer elements based on the desired end use and size of the pan. A two-piece design with lid can be utilized. A single unit involving a continuous extrusion of the finned assembly can also be made which would then be cut to the desired length. Preferably, the fins would be coated with an FDA approved coating, such as provided by General Magnaplate, to facilitate cleaning and meeting food handling requirements.

FIGURES 24, 25, 27, 28, 30 and 31 illustrate the cooling of refried beans using the device 10. It will be noted that the beans are at storage temperature within about two to three hours, rather than the up to twenty-four hours typically taken at the present time without use of the device 10 when done in a walk-in cooler with the same size pan.

FIGURES 24 and 25 show results for 17.5 pounds of refried beans in one pan using device 10 cooled in a 20°F residential freezer unit. FIGURES 27 and 28 show results for 17.5 pounds in one pan using device 10 of refried beans cooled in an industrial walk-in cooler at 40°F. FIGURES 30 and 31 show results for 17.5 pounds of refried beans in one pan using device 10 cooled in an industrial freezer at 20°F.

FIGURES 29 and 32 show various tests with spaghetti sauce by using device 10. In these tests, 19.2 pounds of sauce was placed in a pan using device 10. FIGURE 29 is a test in a 40°F industrial unit and FIGURE 32 is a test in a 0°F to 20°F industrial unit. FIGURE 26 shows the advantage of reheating foods, such as beans, using device 10. The temperature of the beans rises more rapidly than otherwise would be possible to the serving temperature. FIGURE 26 heated 17.5 pounds of refried beans in one pan using device 10 in a 450°F industrial oven.

With reference now to FIGURES 7-10, a first modification of the invention is illustrated as food storage and preparation device 50. A number of elements of device 50 are the same as device 10 and are numbered with the same reference numerals. In device 50, a body 52 is provided which has dove-tail slots 54 therein for receiving the food contact fins 56. The fins 56, in turn, have dove-tail ends 58 which fit within the slots 54. If desired, the fit between fins 56 and body 52 can be a simple sliding fit to ease removal of the fins 56 from body 52 for easy cleaning.

With reference now to FIGURES 11-15, a food storage and preparation device 100 forming a second embodiment of the present invention is illustrated. Again, a number of elements of device 100 are the same as devices 10 and 50, and are identified by the same reference numeral. In device 100, the body 102 has a series of corrugated notches 104 to receive a food contact fin 106a, 106b or 106c. The fins 106a, 106b and 106c, in turn, have corrugated ends 108 to be received within the notches 104. As shown in FIGURES 13A-C, the fins 106a, 106b, and 106c can have varied lengths to adapt the device to a particular size pan. for example, 4 inches, 6 inches and 10 inches in length to fit pans with these depths. As can be seen in FIGURES 12 and 14, both the body 102 and fins 106a, 106b and 106c have pin apertures 110 to receive a pin therein

to lock the fins 106 to the body 102. The modularity also enhances cleaning and handling characteristics.

FIGURE 16 illustrates a device 200 which is formed as a unitary body which can be cast, extruded, molded or machined. In other regards, it is identical to device 10.

5       FIGURE 17 illustrates a device 220 which is formed with a hollow body 222 containing cavity 224 and hollow food contact fins 226 defining cavities 228 along their length. Cavities 224 and 228 are connected and the cavities can contain a material 230 with high heat capacity and heat transfer rate. The material 230 can be a solid, liquid or gas and can be transformed from a solid to a liquid or gas during the heat transfer  
10       process.

FIGURES 18 and 19 illustrate a device 240 which has body 242 with cavity 244 and food contact fins 246 with cavities 248. Again, cavities 244 and 248 are connected. In addition, the body 242 has an inlet port 250 and an outlet port 252 opening through the exterior of the body into the cavity 244. The inlet port 250 can be connected to a  
15       source of heat transfer fluid, such as water or other liquid or gas material, which enters port 250 and flows through the cavities 244 and 248 absorbing heat. The heated fluid or gas is then removed from the outlet port 252 to a heat exchanger for reuse in the device 240 or disposed of. Device 240 permits variation of the heat transfer characteristics of the device by selecting a desired heat transfer fluid flow rate and type  
20       of material.

FIGURE 20 illustrates a device 260 similar to device 240 in utilizing coolant flow therethrough. Because of the coolant flow, the air contact fins 20 are not utilized.

FIGURES 21 and 22 illustrate the use of a temperature monitor 280 in the device 10, but the monitor 280 can be used with any other device described herein. The  
25       temperature monitor gives a visual indication when a portion of the device or the material being heated or cooled has reached a certain temperature. With reference to FIGURE 22, the monitor 280 can be seen to include a housing 282 into which is fit an indicating pin 284, a return spring 286 and a shape memory alloy spring 288. A cap 290 confines the pin and the springs within the housing 282. Below a determined

temperature, the return spring acts between the cap 290 and ridge 292 on pin 284 to maintain the pin retracted within the housing. At the predetermined temperature, the shape memory alloy spring 288 increases in length, compressing the return spring 286, and urging end 294 of the pin 284 outside of the housing to provide a visual indication  
5 that the predetermined temperature has been achieved. For example, the temperature monitor 280 can be designed to actuate at about 140°F or, to react when the temperature is about 40°F.

With reference to FIGURE 23, a removable handle 310 can be employed to assist in placing and removing the device 10 and other devices described herein. The  
10 handle 310 includes a first arm 312, and a second arm 314 connected together by a pivot 316. Each arm has an in turned lip 318 to pass around the bottom of the body of the device to allow the device to be moved.

Although the present invention and its advantages have been described in detail herein, it should be understood that various changes, substitutions and modifications of  
15 parts and elements can be made without departing from the spirit and scope of the invention as defined by the appended claims.

**WE CLAIM:**

1. An apparatus for rapidly changing the temperature of a mass of product, comprising:  
at least one input heat transfer element extending into the mass of product;  
at least one output heat transfer element in thermal contact with the input heat transfer element and exposed to an ambient temperature environment to transfer thermal energy between the product mass and the ambient temperature environment.
2. The apparatus of Claim 1 wherein said at least one input heat transfer element defines a plurality of product contact fins and said at least one output heat transfer element defines a plurality of air contact fins.
3. The apparatus of Claim 1 further comprising a lid for use on a pan containing the mass of product, the lid having at least one slot therein, said at least one input heat transfer element passing through said slot.
4. The apparatus of Claim 1 wherein the mass of product is in a pan, the pan having a bottom, said at least one input heat transfer element contacting the bottom of the pan.
5. The apparatus of Claim 1 wherein the at least one input heat transfer element is detachable from said at least one output heat transfer element.
6. The apparatus of Claim 1 wherein the at least one input heat transfer element and at least one output heat transfer element are formed of a material selected from the group consisting of aluminum, stainless steel, cast iron and copper.



7. The apparatus of Claim 1 wherein the at least one input heat transfer element and at least one output heat transfer element are formed as a unitary body.

8. The apparatus of Claim 1 wherein the at least one input heat transfer element is hollow, the apparatus further including a material within the input heat transfer element to transfer heat between the input heat transfer element and the output heat transfer element.

9. The apparatus of Claim 1 further comprising a temperature monitor for monitoring a temperature of one of said heat transfer elements.

10. The apparatus of Claim 1 wherein said one at least one input heat transfer element is hollow, the apparatus including an inlet port permitting heat transfer material to flow into the hollow interior of the input heat transfer element and an outlet port to remove material from the hollow interior of the input heat transfer element to transfer heat from the input heat transfer element exterior of the apparatus.

11. The apparatus of Claim 1 further comprising a removable handle to move said apparatus.

12. A method for rapidly changing the temperature of a mass of product, comprising the steps of:

placing at least one input heat transfer element within the mass of product; and exposing at least one output heat transfer element in thermal contact with the at least one input heat transfer element to an ambient temperature environment to transfer thermal energy between the product mass and ambient temperature environment.

13. The method of Claim 12 further comprising the step of inserting a plurality of said input heat transfer elements within the mass of product.

14. The method of Claim 12 further comprising the step of removing said at least one input heat transfer element from said at least one output heat transfer element to facilitate cleaning.

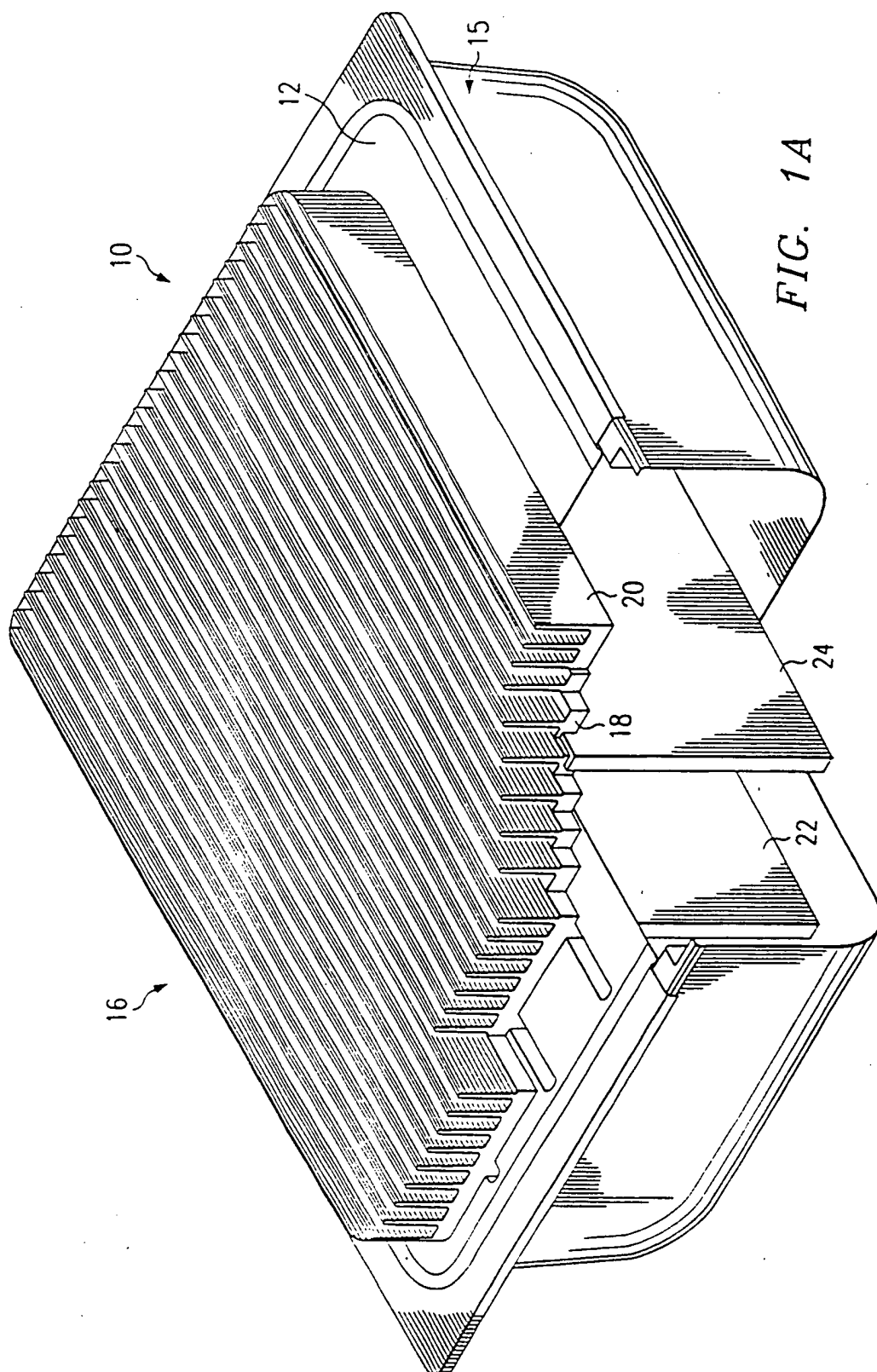
15. The method of Claim 12 further comprising the step of inserting said at least one input heat transfer element through a slot formed in a lid for a pan containing the mass of product to insert said at least one heat transfer element into the mass of product.

16. The method of Claim 1 further comprising the step of passing a heat transfer medium through a hollow interior of said one input heat transfer element to transfer heat to the heat transfer medium.

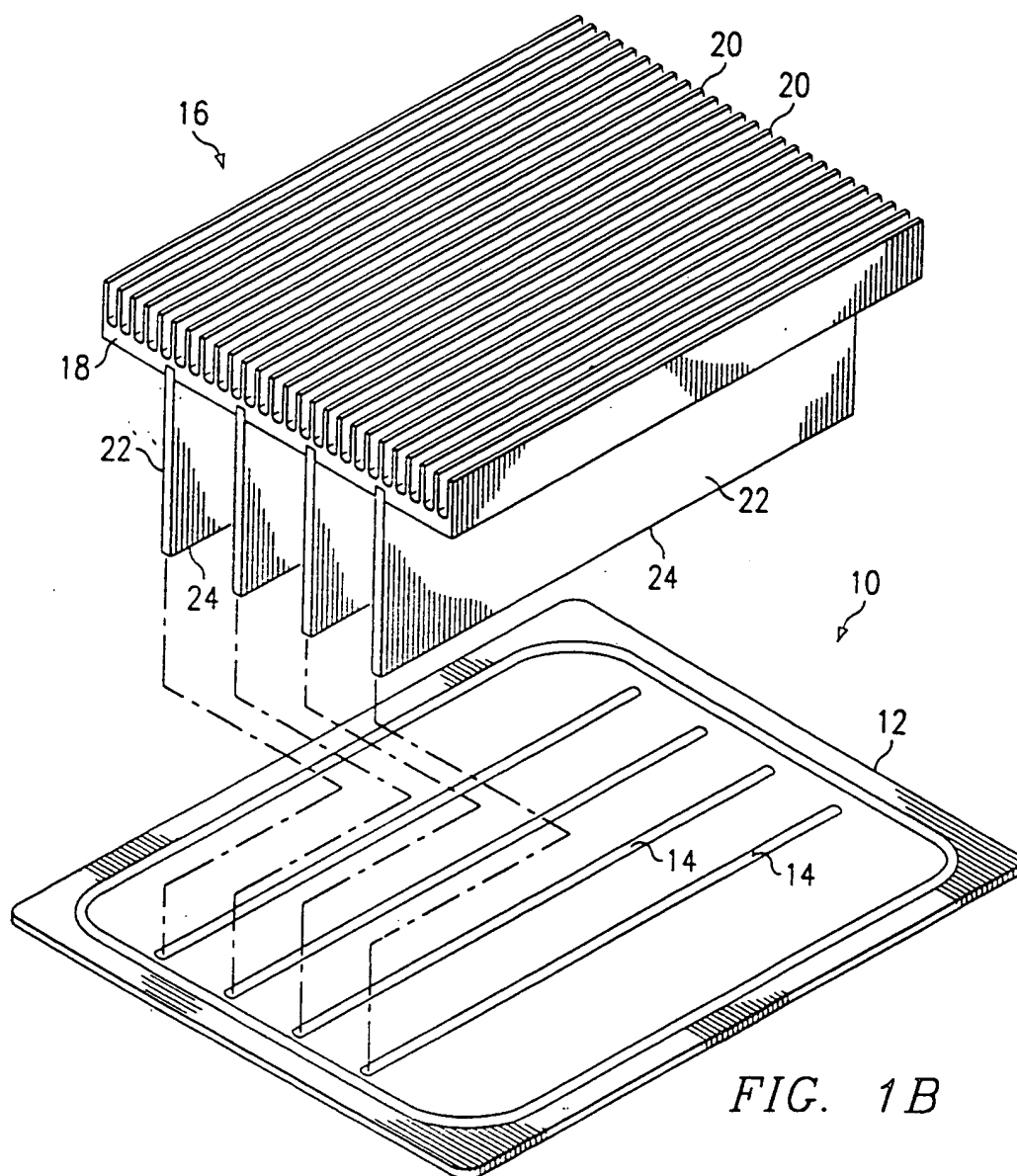
17. The method of Claim 12 further comprising the step of grasping the at least one input heat transfer heat element with a removable handle.

18. The method of Claim 12 wherein the step of placing at least one input heat transfer element within the mass of product includes the step of placing the at least one input heat transfer element within a mass of food.

19. The method of Claim 12 further comprising a step of providing a visual indication when the at least one input heat transfer element has achieved a predetermined temperature.



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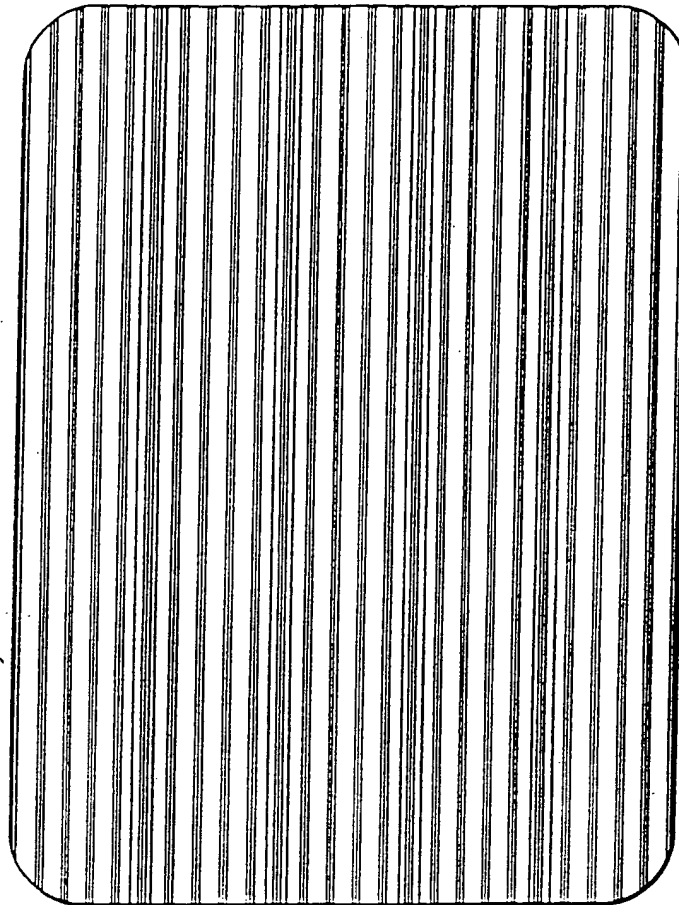


FIG. 2

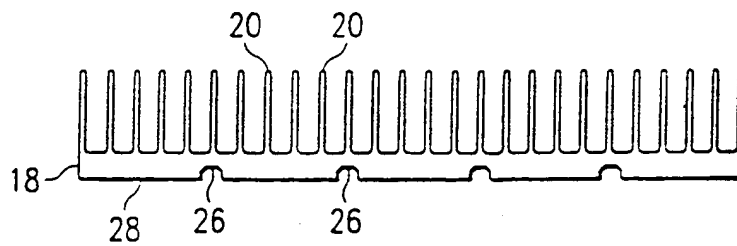


FIG. 3

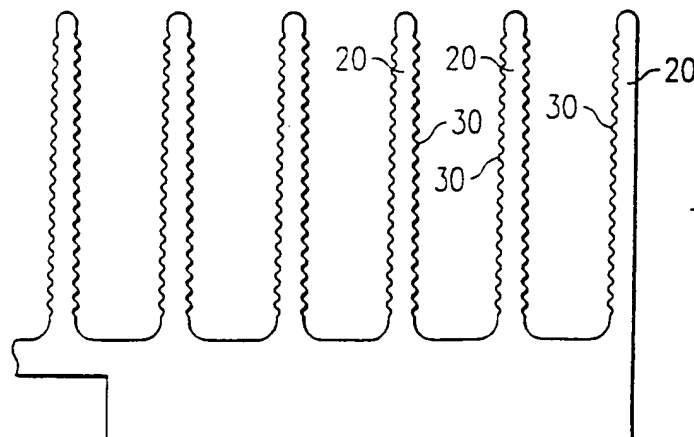


FIG. 4

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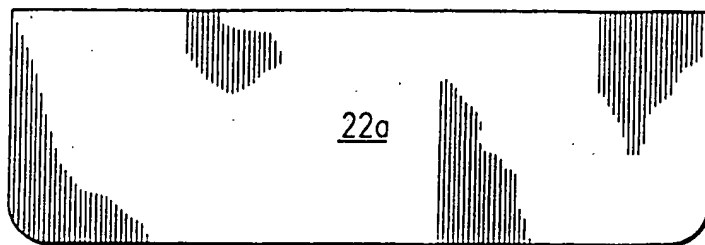


FIG. 5

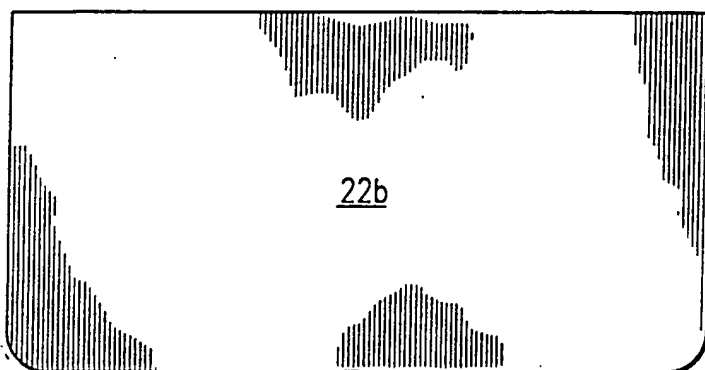


FIG. 6

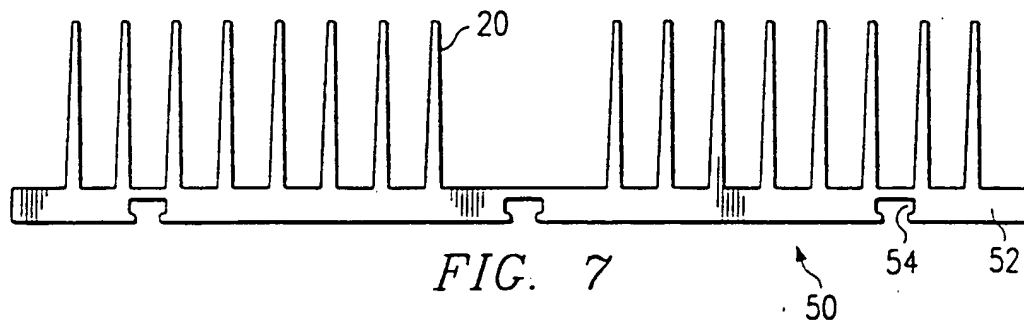


FIG. 7

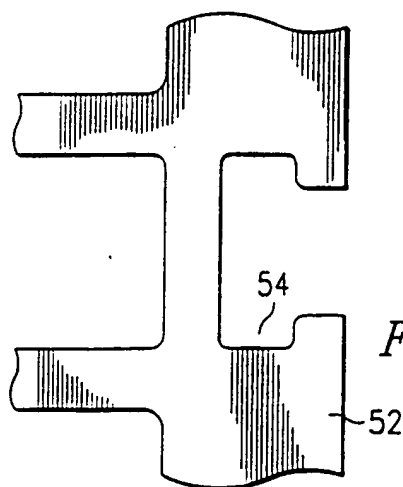


FIG. 8

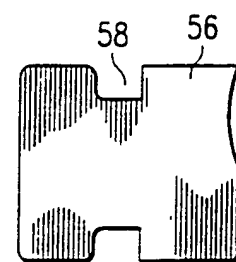


FIG. 9

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FIG. 10

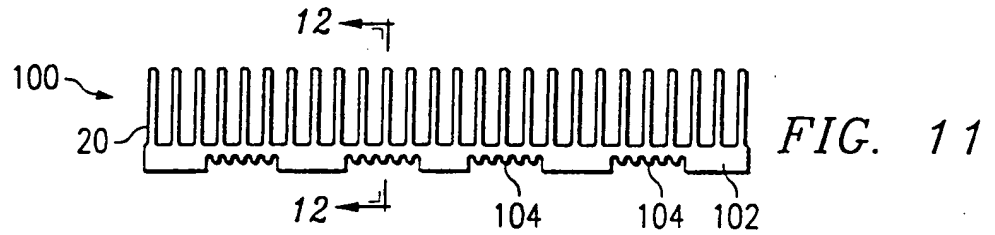
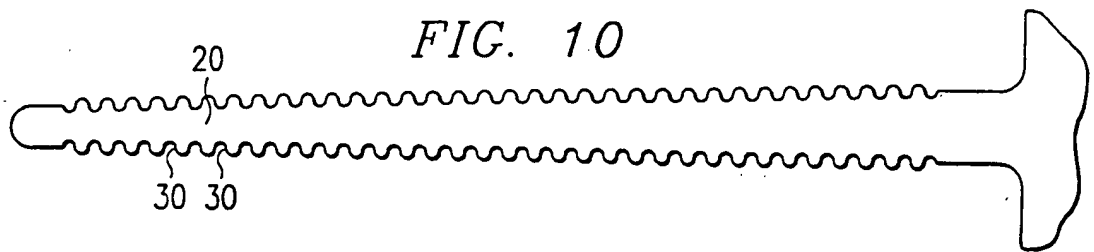


FIG. 11

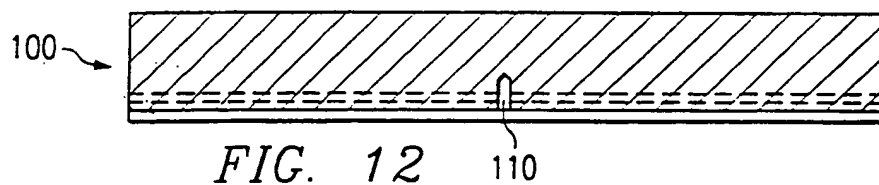


FIG. 12

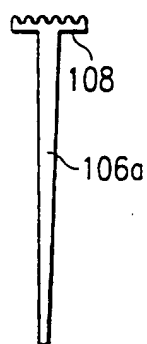


FIG. 13A

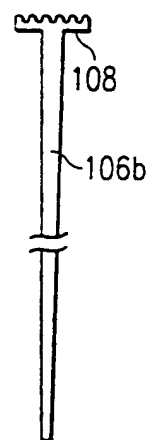


FIG. 13B

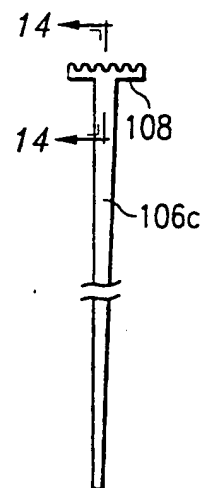


FIG. 13C

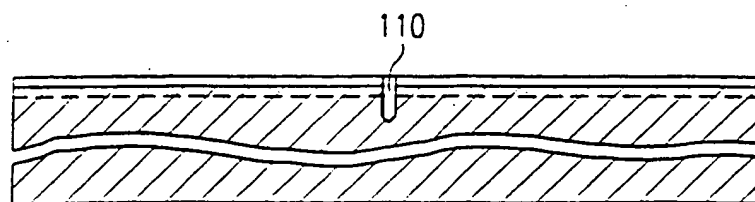
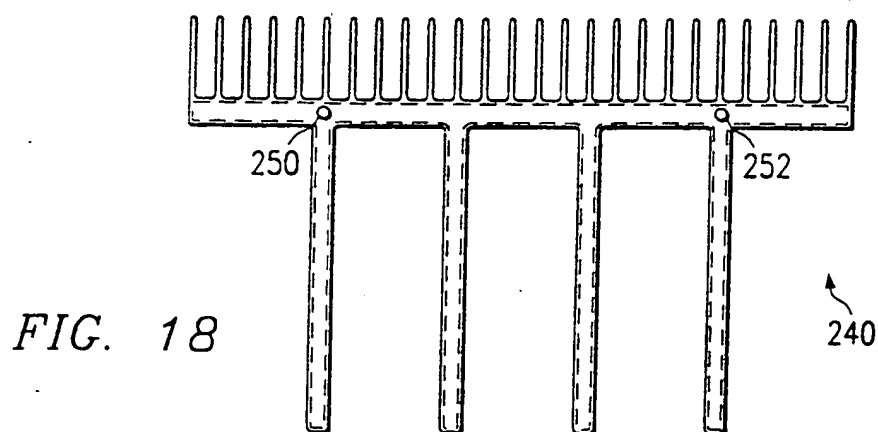
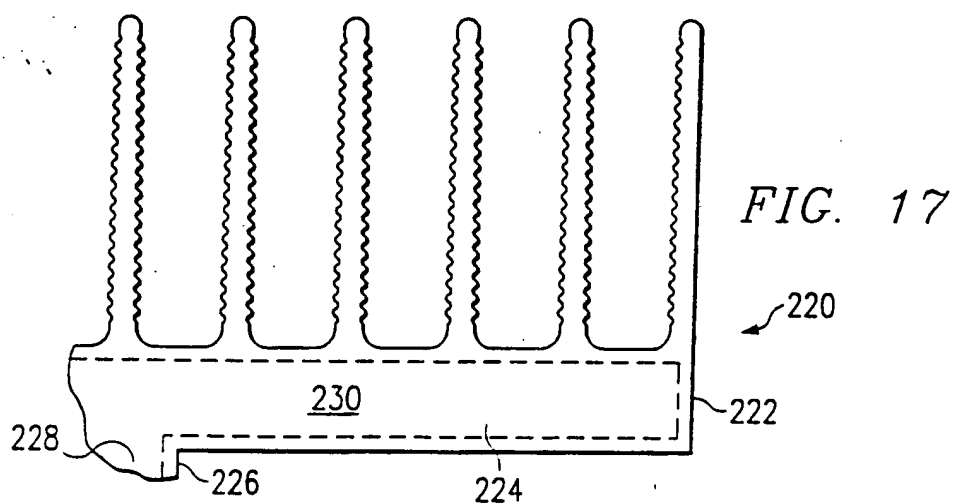
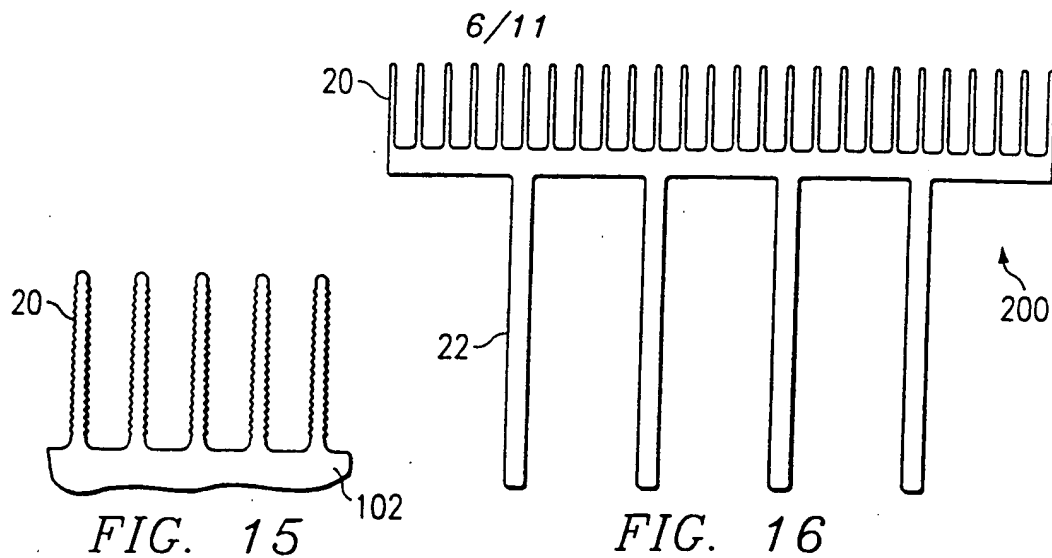


FIG. 14





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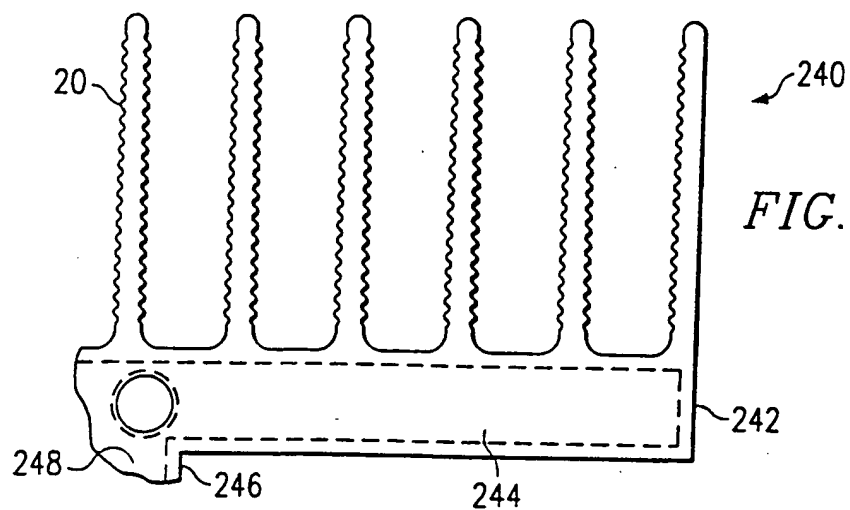


FIG. 19

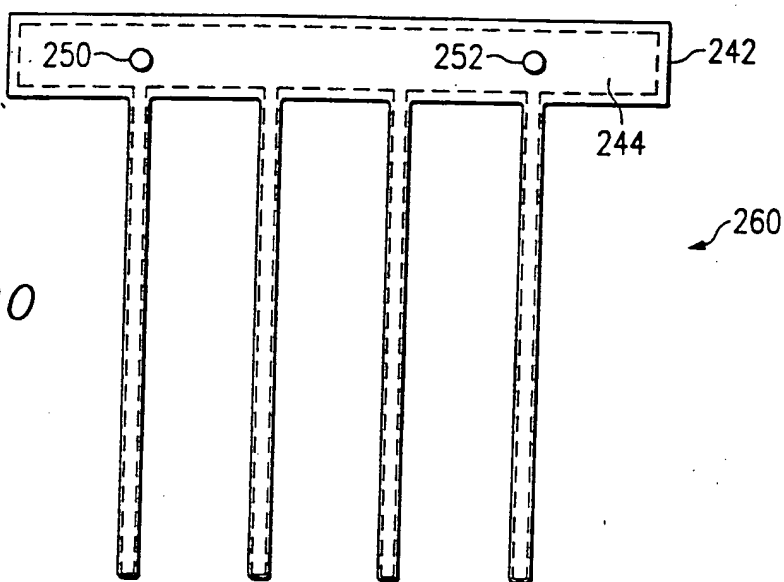


FIG. 20

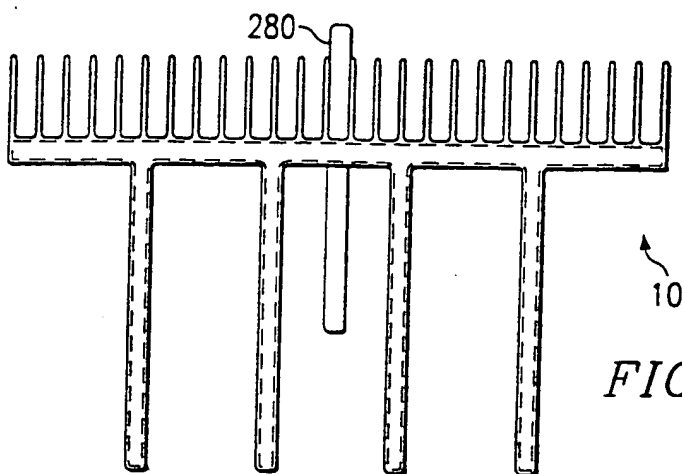


FIG. 21

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FIG. 22

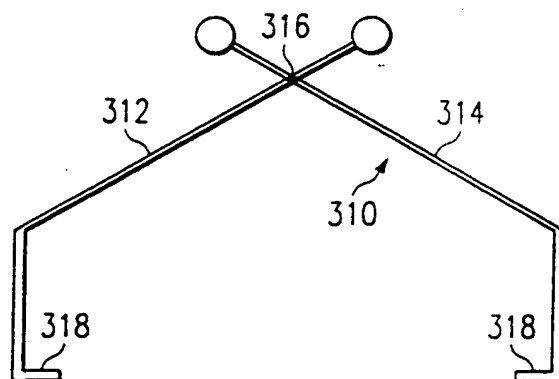
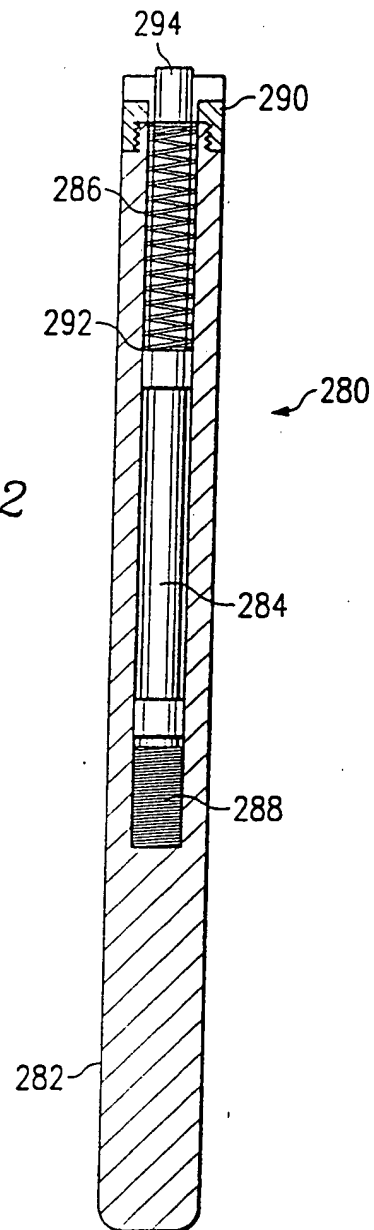


FIG. 23

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FIG. 24

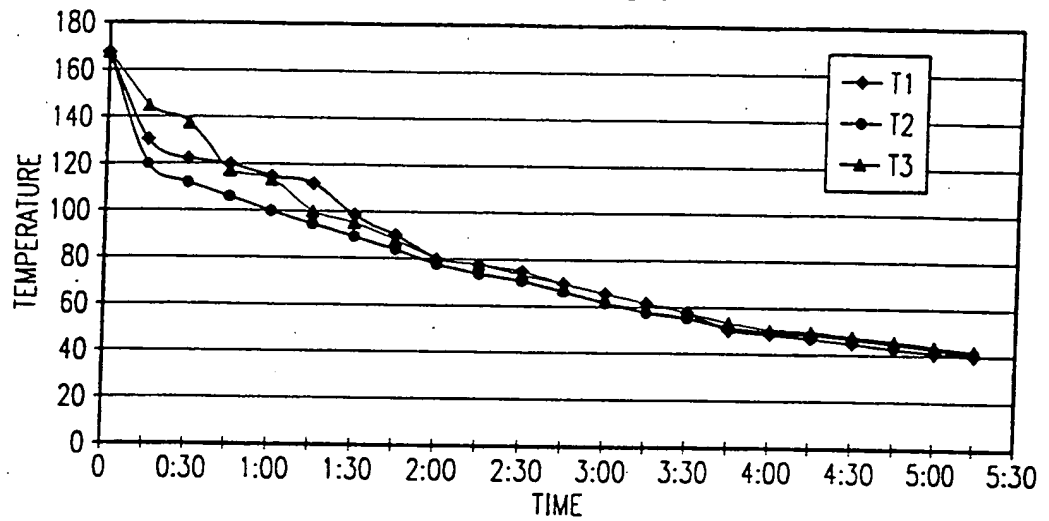


FIG. 25

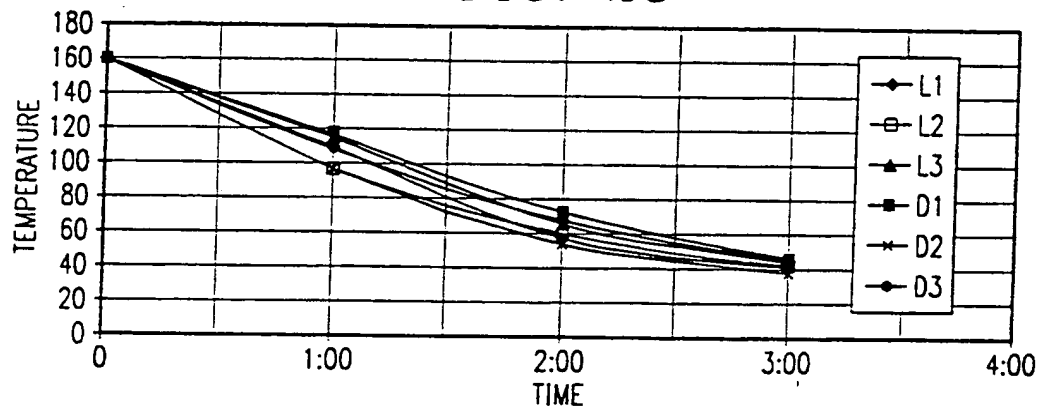
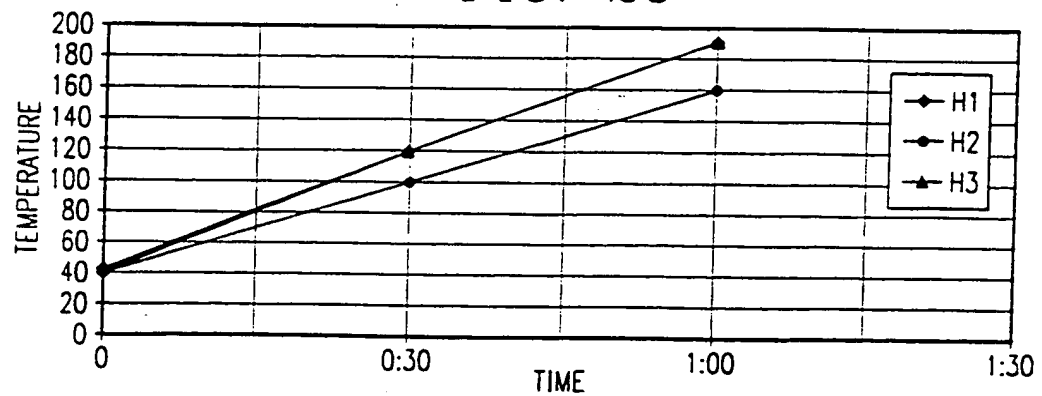


FIG. 26



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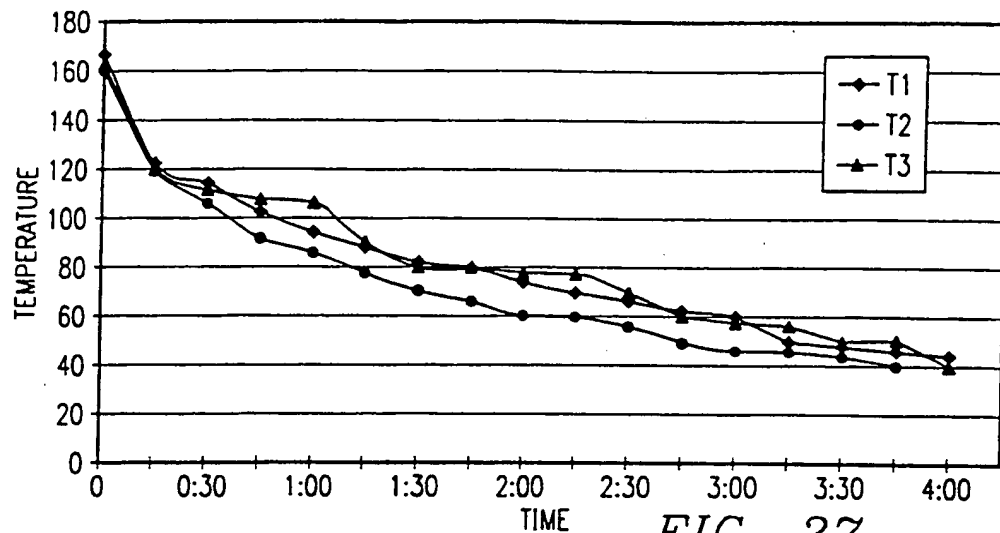


FIG. 27

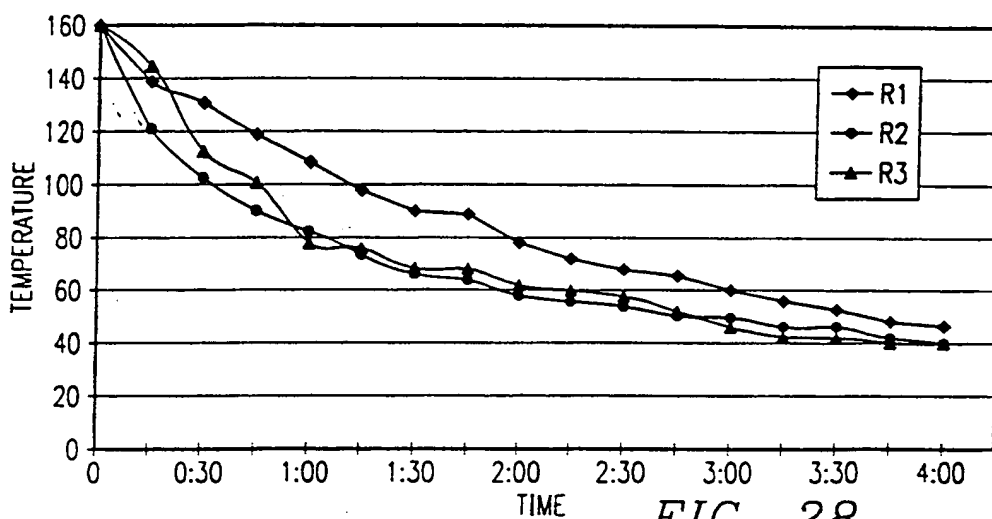


FIG. 28

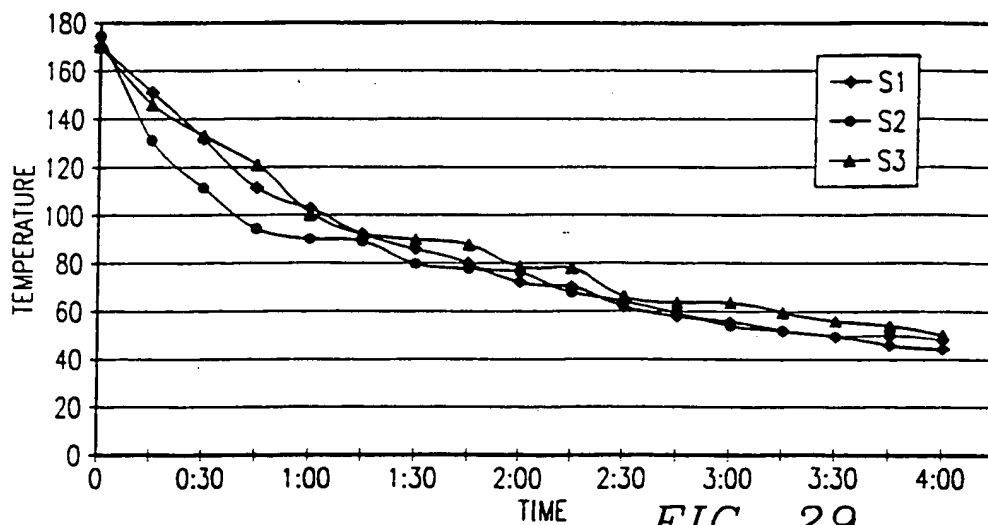


FIG. 29

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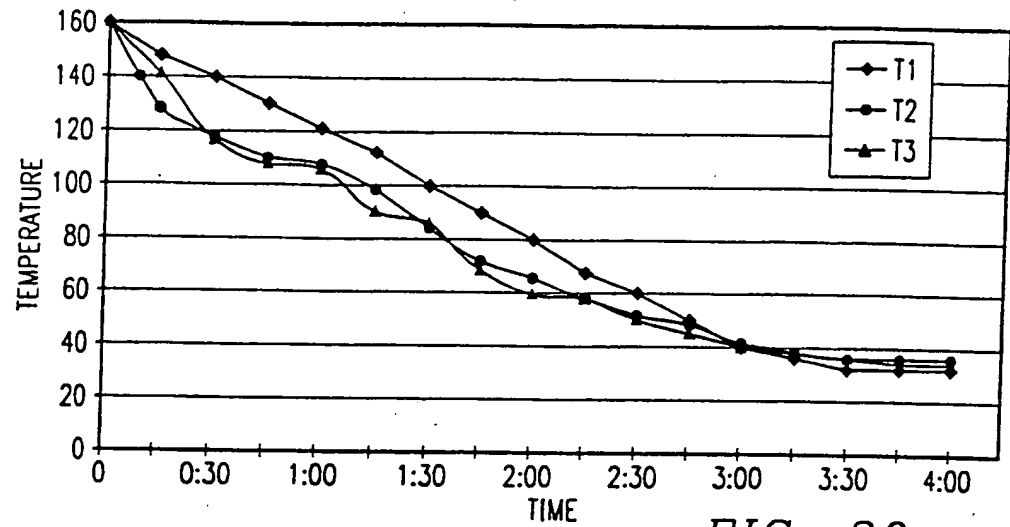


FIG. 30

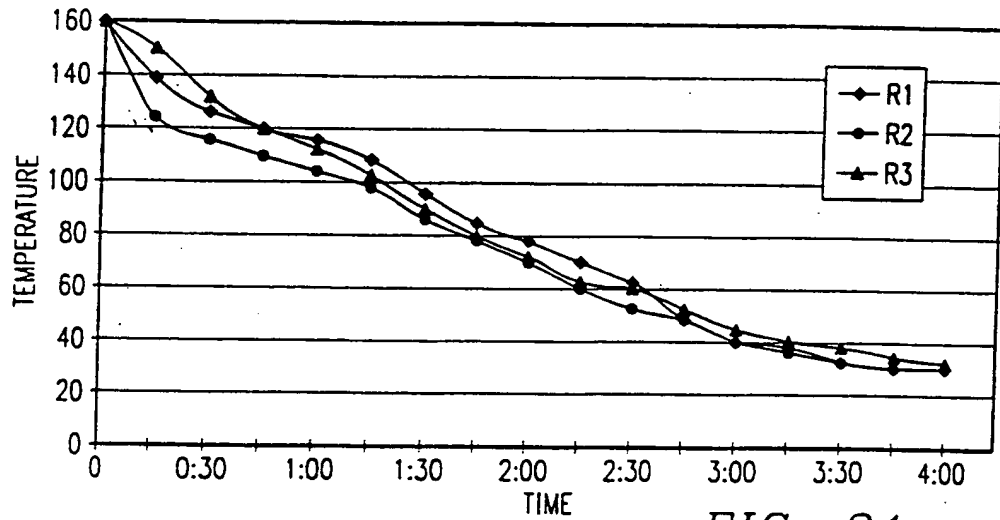


FIG. 31

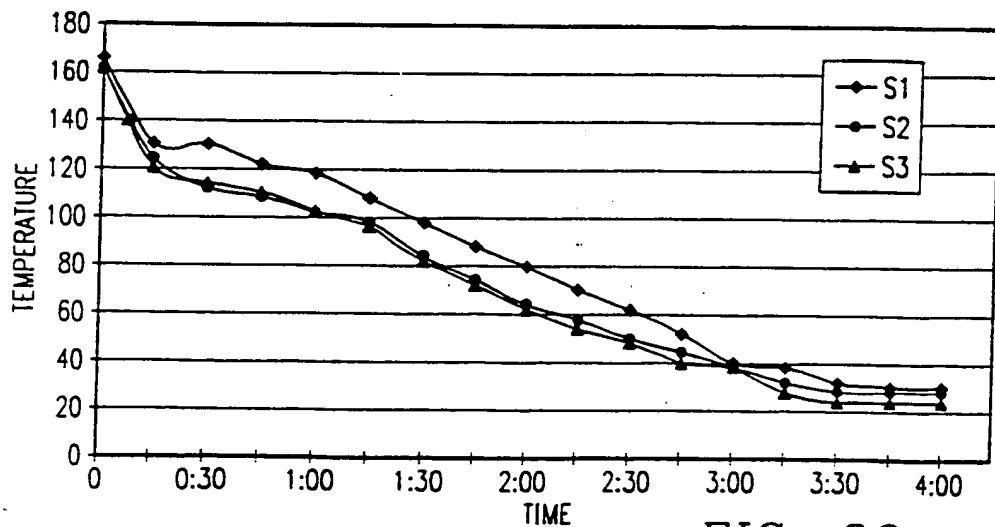


FIG. 32

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 98/17433

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 6 F2503/08

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 F25D A47J A47G F25C F28D A23L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 20 27 527 A (ENERGY CONVERSION SYSTEMS INC.) 10 December 1970	1,5,7-9,
Y	see page 5, line 29 - page 7, line 37; figure 1	12,18,19
Y	DE 32 14 886 A (PHILIPS PATENTVERWALTUNG) 27 October 1983 see page 1, line 1 - page 2, line 4; figure 1	2,10,13, 16
Y	US 4 785 875 A (MEIJER ROELF L ET AL) 22 November 1988 see column 3, line 4 - line 20; figure 1	2
	-/--	10,13,16

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

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"&" document member of the same patent family

Date of the actual completion of the international search

23 November 1998

Date of mailing of the international search report

03/12/1998

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Jessen, F

# INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 98/17433

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 097, no. 004, 30 April 1997 & JP 08 322530 A (HOSHIZAKI ELECTRIC CO LTD), 10 December 1996 see abstract ---	1,3,7,8, 12,13, 15,18
X	FR 2 575 814 A (CAPPA ROBERT) 11 July 1986  see page 3, line 15 - page 4, line 3; figure 1 ---	1,7,8, 12,13, 15,18
X	FR 1 586 050 A (MARCEL DEBROCK) 6 February 1970 see page 2, line 13 - page 3, line 4; figure 1 ---	1,4,6-8, 12,18
X	WO 90 14771 A (OD T I PISCHEVOI PROMYS) 13 December 1990 see abstract; figure 1 ---	1
A	FR 445 563 A (M.CHARLES-CONSTANT LECLAIRE) 14 November 1912 -----	

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 98/17433

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
DE 2027527	A	10-12-1970	FR 2045847 A GB 1275846 A	05-03-1971 24-05-1972
DE 3214886	A	27-10-1983	NONE	
US 4785875	A	22-11-1988	DE 3871493 A EP 0316044 A JP 1193591 A	02-07-1992 17-05-1989 03-08-1989
FR 2575814	A	11-07-1986	NONE	
FR 1586050	A	06-02-1900	NONE	
WO 9014771	A	13-12-1990	NONE	
FR 445563	A		NONE	